MICROWAVE LOADS - A NEW ERA

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Introduction

The selection of a waveguide load for either systems design or microwave test is a compromise between a number of issues. This paper attempts to capture the factors that need to be considered and offers some solutions to those problems. The technology described is by no means exclusive to Credowan or its sister Chelton companies, although some particular configurations are relatively unique.

What is a Load ? (Fig. 1)

In simplistic terms, the load is a means of converting microwave or RF energy into heat with the maximum thermal efficiency and the maximum absorption. The quality of many measurements of waveguide-related systems is often dependant on the load that is feasible and available to be used. The selection of the optimum load I now intend to discuss.

The selection of that optimum load I will now try to identify into its four constituent parts, namely space, power handling, cooling medium available and cost.

Space

The best possible load is one that is infinitely long. This load will offer an almost perfect VSWR, but in reality is impractical for two reasons. The first of those reasons is that were the load to be extremely long, it would become unhandleable, and secondly that the key part of any waveguide load is in the first 10% of material which sees the power arriving down the waveguide. The longer the load is, the smaller amount of material this has, and therefore the difference in heating effect between the front and the rear end of the load can be counterproductive and cause fracture or loss of performance. Anybody in the building who has handled a high spec tapered load such as that shown on the demonstration table will know what I mean. The other consideration should be that where significant power exists there is clearly a need to supply this efficient machine for conversion of RF energy into heat sink, normally fins or water. However, as I will discuss later in this paper, there are other options which can be considered.

Power Handling

The power handling of waveguide loads is obviously fundamental in the selection process and both peak and average powers must be considered, although average power tends to be the dominant force in the selection process. I will explain during this paper different ways and try to give some guidance on typical power handlings on typical loads. However, safety margins must also be considered as instantaneous heating effects for even sub-one-second periods can have an effect on both the use and the life of a waveguide load.

Cooling Medium Available

For low power precision loads, normally used by most of us in their microwave laboratories, power levels are obviously insignificant as the source of the RF energy is generally low power network analyser-based systems. However, in the real world, particularly in the modern satellite and radar industries, power handling must be taken very seriously and methods that can safely remove heat from the waveguide load network must be addressed. The first stage is clearly to use the familiar fin. Design of these fins needs to be undertaken carefully as interaction is very common. The next stage clearly is to use a water or other liquid cooling. It should be remembered however that water-cooled loads should never be operated in a dry fashion as this is not only detrimental to the health of the load, but could also be detrimental to the health of any test engineer standing within range of an exploding metal load. I will also consider on this paper later the use of water dielectric loads which in many ways combines the benefits of both.

Cost

ARMMS is a technical body, but in the modern academic and industrial environment one can never exclude cost from the equation. Air-cooled loads are generally cheaper than water-cooled loads because of a lower part count, but one of the main costs involved in the manufacture of small quantity loads for test applications is in the design and the tooling and consultation with one of the major load manufacturers throughout the world will often realise a low-cost option. This I suggest is always undertaken. That is perhaps however for another time and place.

Basic Load Options

A) Waveguide Housing & Insert
B) Inverse Moulded Insert in Round Waveguide
C) Multiple Tiles or Elements in Rectangular Waveguide
D) Coil/Lossy Round Waveguide Transmission Line
E) Water Dielectric Windows or Cone

Type A) - Low or Medium Power Loads

Two basic types here: The precision fixed or sliding load used for measurement or calibration purposes. Here the other three factors to some extend do not apply and we are looking for the optimum VSWR. VSWR's of 1.005 are achievable if the load is big enough and the control of the material is accurate enough. We should however factor into this equation that waveguide loads are like most waveguide devices in that they are inherently spot-frequency device and that we should trade off frequency bandwidth against a VSWR slope. Always be sure that you know the frequency that your load needs to work at prior to opening a discussion.

The second type of load in this area are specialist short low cost units normally specified into systems. These can have VSWR's as bad as 1.3 :1, but for many low-cost non-critical VSWR applications these can be as cheap as a waveguide co-ax transition.

Types B) and C) (Fig. 2)

Without talking about more significant power handlings, these are either finned with either an instert or inverse moulded application. The inverse moulded style is particularly interesting in that this novel technique allows for the maximum thermal transfer. The traditional cone load is therefore inverted into a cone. If you would like to know a little bit more about this load, I will be happy to discuss it after my paper has been given and show you some typical examples. The key here is selection of the filler material to handle the thermal demands. Waveguide loads of this nature can happily work at temperatures in excess of 500°C and still have meaningful life and a robust performance provided the thermal paths are good and the loads are well-designed.

Typical application might be:

10W	@	10GHz	Housing, Insert
100W	@	10GHz	Finned, Insert
1kW	@	10GHz	Finned, I.M.I. Type
2.5kW	@	10GHz	Water Jacket, I.M.I. Type
250kW	@	10GHz	Water Jacket, Ferrite Tile

Type D) - Coil Loads (Fig. 3)

These are a particularly novel design where we use lossy transmission line specifically designed to dissipate power. We can achieve power handlings for an air-cooled load far in excess of traditional methods, again an example of this type of load will be available for review. These loads however are not fundamentally broad-band loads, so bandwidth should be considered if these are selected.

Type E) - Water Dielectric Loads (Fig. 4)

The final loads I will review are water-dielectric loads. One of the early types of load used for testing high power radars was known as a glass load. These were notoriously fragile and older members of our community will remember how easy they were to break. In our case we use highly robust PTFE machined cones which allow the RF energy to directly heat the water, which is continuously circulated in order to remain cool. This particular technology has been in substantial use for 20 or 30 years to our certain knowledge and really is an optimum way of achieving a compact, but high power performance load. These can also be very broad-band and surprisingly low-cost.

Conclusions

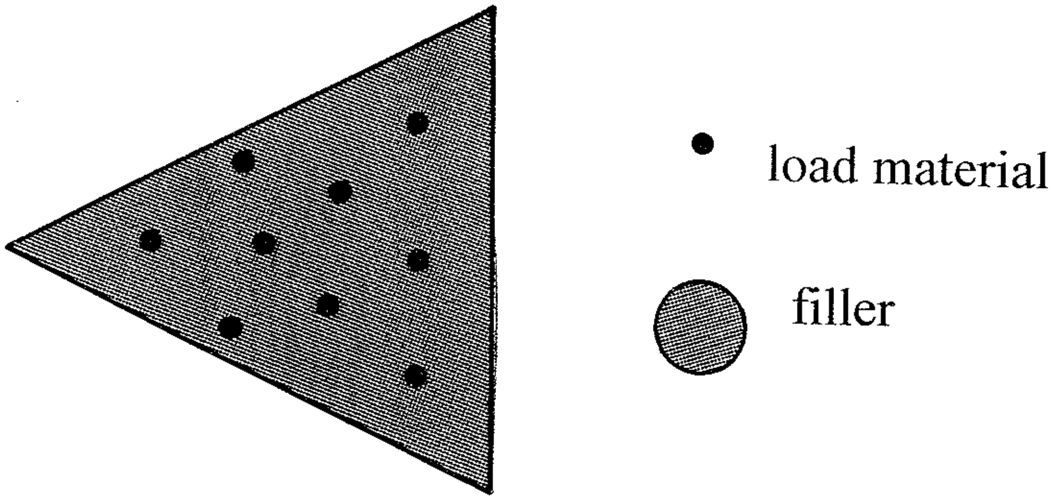
What is a load ? I will turn to an earlier slide at this point and remind you that a load needs to be carefully designed taking into account all key factors. The key specifications issues are unquestionably:

- Power Handling, Peak and Duty Cycle.
- Frequency and Waveguide Size
- Flange Type and Material
- Orientation
- Cooling Type and Fittings if appropriate
- Weight and Size

Waveguide loads are a mature technology and Credowan has engineers with 35 years' experience heading up the load division, project name being Microsorb. Please feel free to contact us.

Thanks is owed to Paul Griffin and Steve McBride in the preparation of this paper.

what is a load?



* control of the mix is the key 3-5% is normal.

* carbonyl iron or silicone carbide is normal.

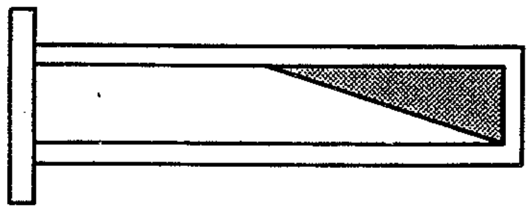
* silicone rubber, alumina or mica are good for fillers.

* ferrite tiles for highest peak powers.

* HOWEVER, dielectric loading is a good option.

Fig. 1

TYPES B) & C)



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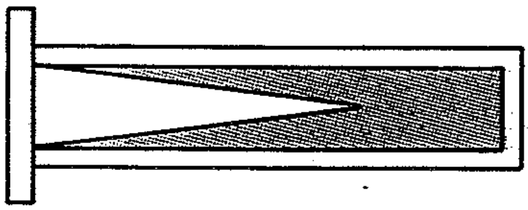
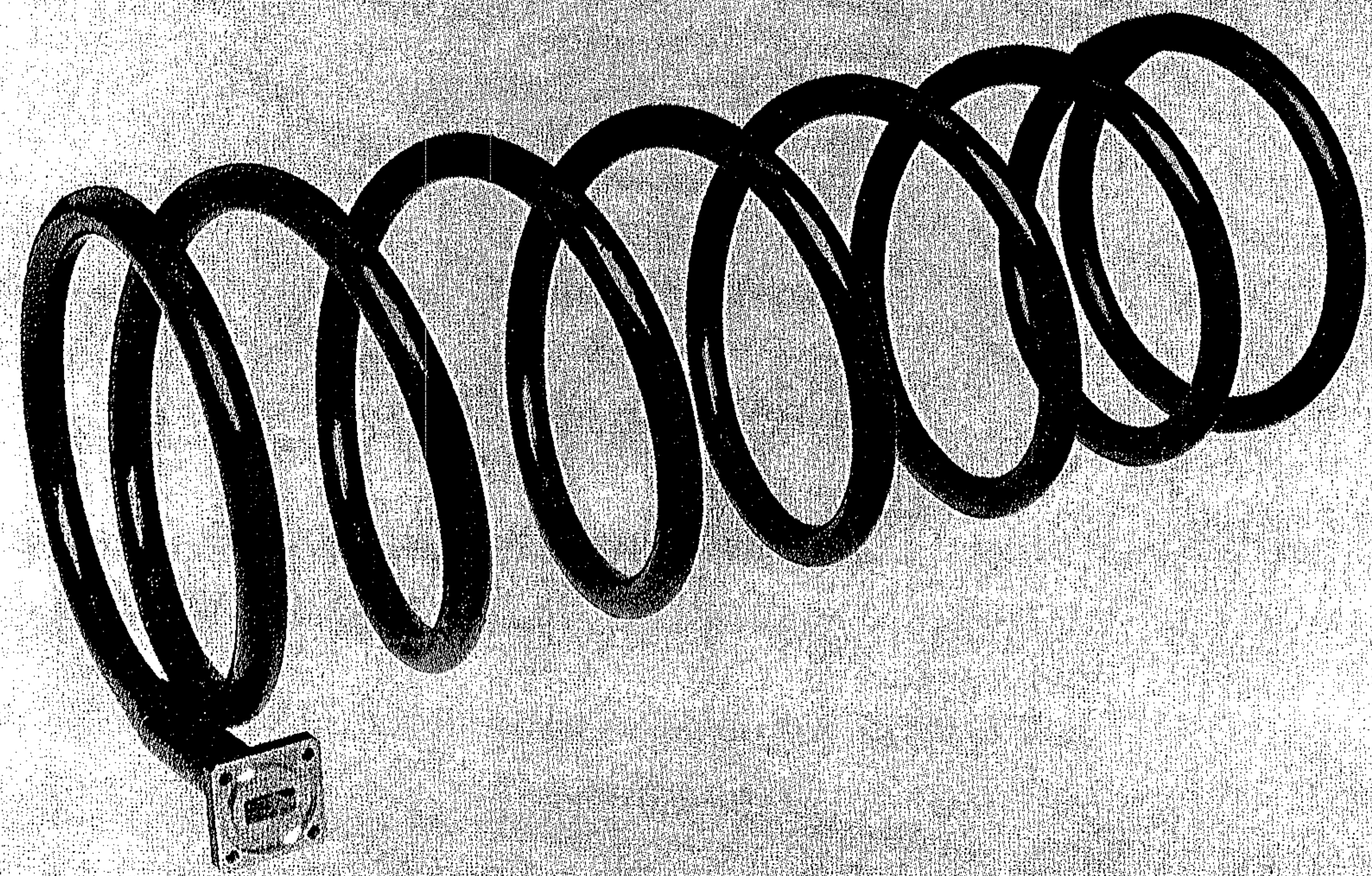


INVERSE MOULDED

Fig. 2

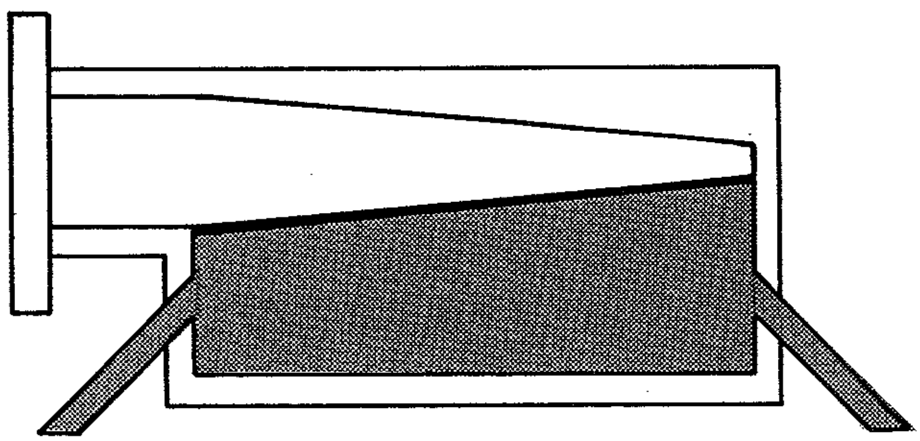


TYPE D)

Fig. 3

E)

WATER DIELECTRIC



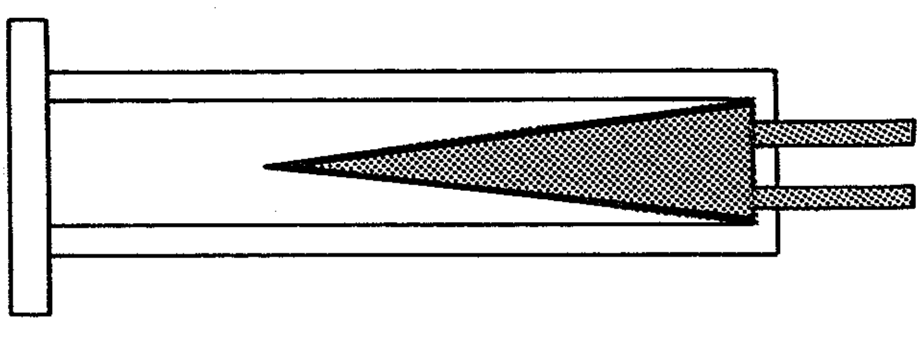


Fig. 4